

Oral Irrigator Design Based on the Kano Model and Kansei Engineering

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Abstract:

Using Kano model and perceptual engineering method, a tooth punch used by young people is studied and designed. The Kano model was used to analyze the demand of young consumers for dental appliances, the type of demand quality and the order of importance. The perceptual vocabulary is screened through investigation, and the semantic difference method is used to analyze the data after the sample database is established, so as to convert the intuitive feelings of consumers into quantitative data and apply it to the design. It is found that young consumers have a high demand for the appearance of tooth punches. They hope to meet the basic functions, fashion trends and aesthetic needs. Based on the research results, the design of tooth punches is completed. Kano model and perceptual process can fully tap the various needs of users for products, and sort them according to the importance. It can guide the design of tooth puncher and carry out design practice from the perspective of users.

Keywords:

Kano Model, Kansei Engineering, User Demand, Product Design

1. Introduction

As people become increasingly concerned about oral health, various oral care methods have emerged. In addition to basic products such as electric toothbrushes and dental floss, oral irrigators are gradually becoming popular. The domestic market for oral irrigators is growing rapidly, even maintaining a growth rate of 11.26% during the pandemic. By studying user needs and emotional intentions and integrating the methods of emotional engineering, the user's inner feelings can be transformed into captured data, which can then be applied to product design. This provides guidance for designing attractive products that meet consumer functional and aesthetic needs.

2. Related notion and research status

2.1. Kano model

Inspired by Herzberg's Two-Factor Theory, Professor Noriaki Kano of Tokyo Institute of Technology formally proposed the Kano Model in the 1980s in the journal

“Quality”. The Kano Model is based on analyzing the impact of user needs on user satisfaction and reflects the nonlinear relationship between product performance and user satisfaction. Based on the relationship between different quality characteristics and user satisfaction, he divides the quality types of products or services into five categories. Must-be Quality, which is a basic requirement that must be met, and the user satisfaction does not increase significantly when this characteristic is met, but the satisfaction will be greatly reduced when it is not met. One-dimensional Quality, which is a requirement that significantly increases user satisfaction when it is met, and does not significantly reduce user satisfaction when it is not met, and should be given priority for improvement. Attractive Quality, which does not affect user satisfaction if this type of requirement is not provided, but user satisfaction will increase dramatically when this requirement is met. Indifferent Quality, which means that user satisfaction will not significantly change whether this type of requirement is provided or not. Reverse Quality, which means that the user does not have this requirement, and satisfaction will decrease if it is provided.

After years of extensive practice and application, the Kano Model has been proven to be a useful tool for classifying and prioritizing user needs and is widely used in product and service research and user needs identification. The Kano Quality Type Evaluation Table is shown in Table 1. In this study, a Kano Model questionnaire was used to conduct a classification survey of the requirements for oral irrigator product design, and quantitative analysis was conducted to obtain the quality types and importance rankings of the requirements.

Table 1. All tables are to be numbered using Arabic numerals.

		Reverse problem				
		like	certainly should	not care	accept reluctantly	don't like
forward problem	like	Q	A	A	A	O
	certainly should	R	I	I	I	M
	not care	R	I	I	I	M
	accept reluctantly	R	I	I	I	M
	don't like	R	R	R	R	Q

2.2. Kansei Engineering

Kansei Engineering is an interdisciplinary field that combines sensibility and engineering. Sensibility engineering uses various methods to quantitatively analyze users' sensibility experiences and combined with product features[2]. Then design products that meet their preferences based on this analysis.[3]

In Japanese, “Kansei” has a broader meaning than “emotion” and encompasses feelings of the mind, aesthetic senses, and taste. Sensibility engineering is a dynamic process that changes with time and trends. It is essentially a set of product development theories that apply users' expectations to design, transforming sensibility images into concrete design parameters. This human-centered design method can compensate for designers' tendency to focus solely on product functionality and appearance, while neglecting users' psychological expectations.

Kansei engineering is widely used in the development of product design. For example, Lai is based on Kansei engineering to explore the unique needs of car users, and develops an application system for the appearance design of new energy vehicles to help its production. [4] Bruno Razza surveyed users' emotional needs for

disposable razors, and found that product features were moderately correlated with users' emotions.[5] Chuan conducts a statistical analysis of the sentimental research data to discover the most meaningful design elements to improve the design and sales of sunglasses. [6]

This article's implementation procedure for sensibility engineering will obtain users' sensibility evaluations of products through methods such as questionnaires, interviews, and semantic differential analysis, determine the correlation between sensibility vocabulary and product design, and clarify design direction through analysis.

3. User requirements analysis

3.1. User research

Based on the results of desktop research, the gender ratio of water flosser users is roughly equal between men and women, with slightly more female users. The age of users is mainly concentrated between 18 and 45 years old, and their income is mainly in the range of 3000-7000 yuan. According to the research, most people still maintain brushing their teeth twice a day for 1-3 minutes each time for oral care, with only a few people insisting on other oral care habits such as rinsing after meals. In terms of the use of oral cleaning products, up to 60% of users use water flossers incorrectly and do not regularly replace the nozzle. On the other hand, most consumers are willing to spend a higher cost to improve their oral problems, such as tooth decay, oral bleeding, tooth sensitivity to cold and heat, and other issues. However, their busy work, high treatment costs, and complicated treatment processes can prevent them from seeking treatment. The existing users of water flossers are mainly young and middle-aged people (18-45 years old) who attach great importance to oral health and appearance, and most of them have good behavioral habits. Despite this, oral problems are still common among middle-aged people, mainly due to a lack of oral care knowledge.[7]

3.2. User portrait

During the preliminary research stage, detailed user research is necessary. By focusing on user profiles to identify the target audience of the product, the core issues of the product can be more clearly identified, the foothold and direction of the product can be pinpointed, and real needs can be explored from the user's perspective. The following is a user profile for water flosser users, as shown in Table 2.

Table 2. User portrait

	student	young and middle-aged
use story	The dental punch is too large, which is not conducive to carrying it outside	Insufficient water storage capacity of the dental punch
	Excessive water pressure can easily damage the gums	Gums and teeth are fragile and sensitive, causing discomfort during use
	The appearance is not beautiful, and it is a bit awkward to use outside	There are too many nursing modes and don't understand the instructions
User pain points	Lightweight and portable design	Large volume, difficult to store too many nursing modes that are not easy to understand
User demands	Detachable water tank, compact design	Reasonable nursing model to meet the needs of different users
	Beautiful appearance and fashionable trend	Easy to clean and does not breed bacteria

	Easy to use, simple steps	Easy to operate interactive mode
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4. User demand analysis based on KANO model

4.1. Demand index determination

Based on in-depth research on user needs, the usage requirements of water flossers were ultimately divided into three levels: basic functional level, unique functional level, and appearance level, containing a total of eight specific requirements, as shown in Table 3.

Firstly, the basic functional level distinguishes the usage functions of water flossers and assesses users' degree of need for different functions. Secondly, the unique functional level is used to determine which additional functions are required by users. Thirdly, the appearance level classifies the design direction of the water flosser's appearance, aiming to understand users' preference for the appearance of water flossers.

Table 3. Oral irrigator demand keywords.

type	demands	number
basic function	Large water tank, no need for refilling	S1
	Multiple nursing modes to meet different needs	S2
	detachable water tank, lightweight and portable	S3
	Gravity ball design, multi angle water outlet	S4
feature function	Storage nozzle design	S5
	UV sterilization	S6
appearance design	Ergonomically designed for easy grip and a smooth feel	S7
	Fashionable color scheme, beautiful appearance	S8

The Kano Model questionnaire was used to analyze different types of demands by asking questions in both positive and negative aspects. Each question had five possible answers, which were "Very Satisfied", "Must Have", "Indifferent", "Barely Acceptable", and "Very Dissatisfied", corresponding to scores of 4, 2, 0, -2, and -4, respectively. The questionnaire format can be found in Table 4. The questionnaire was distributed online, and 11 valid responses were obtained.

Table 4. The Kano model questionnaire form.

question	like	certainly should	not care	accept reluctantly	don't like
If there are multiple nursing modes	☐	☐	☐	☐	☐
If there are no multiple nursing modes	☐			☐	☐

4.2. Reliability

Reliability refers to the consistency of ratings among the participant group. In this study, SPSS 22.0 software was used to validate the reliability of the Kano questionnaire for toothbrush design requirements. Although there is no absolute value standard for the alpha coefficient, an alpha coefficient of 0.7 is widely accepted as a reliability standard, and items with an alpha coefficient lower than 0.35 should be rejected. A reliability coefficient of 0.6 is acceptable, but it is best to be between 0.7 and 0.98, and coefficients lower than 0.35 should be rejected. The reliability and

validity analysis of the Kano questionnaire are shown in Table 5. The overall Cronbach's α value is 0.832.

Table 5. Kano questionnaire reliability.

Reliability statistics	
Cronbach's α	N
.832	16

4.3. Requirement quality type identification

The traditional Kano quality classification method has a relatively simple determination process, which can cause quality attribute misjudgments when the statistical values of two quality types are relatively close. From the preliminary statistical results of the Kano questionnaire, it can be seen that the indifferent quality (I) is relatively close to other qualities, which is not conducive to correctly identifying the true quality type of this indicator.

The traditional Kano quality classification method has a relatively simple determination process, which can cause quality attribute misjudgments when the statistical values of two quality types are relatively close. Therefore, the Better-Worse coefficient calculation method is used to assist in identification. Its calculation method is:

$$\text{Better} = (O + A) / (M + O + A + I) \quad (1)$$

$$\text{Worse} = (O + M) / (M + O + A + I) * (-1) \quad (2)$$

The Better-Worse coefficient indicates the impact of increasing or decreasing a particular requirement on user satisfaction. When both the Better value and Worse absolute value are greater than 0.5, it represents an Expected Quality (O). When both the Better value and Worse absolute value are less than 0.5, it represents an Irrelevant Quality (I). When the Better value is greater than 0.5 and the Worse absolute value is less than 0.5, it represents an Attractive Quality (A). When the Better value is less than 0.5 and the Worse absolute value is greater than 0.5, it represents a Must-be Quality (M) [8]. By combining traditional classification and the Better-Worse classification method, a more comprehensive identification of the quality type of requirements can be achieved. The statistics and classification of the quality types of requirements for dental flosser design are shown in Table 6.

Table 6. Statics and classification of demand quality types of oral irrigator.

function	KANO attribute	Better Coefficient	Worse Coefficient
3.removable water tank,lightweight and portable	attractive	60.00%	-20.00%
7.ergonomic easy to hold desig,smooth feel	attractive	60.00%	-20.00%
4.gravity ball design,multi angle water	undifferentiated	55.56%	-33.33%
8.fashion color matching,beautiful shape	undifferentiated	50.00%	-30.00%
6.UV sterilization	undifferentiated	50.00%	-20.00%
5.storage nozzle design	undifferentiated	40.00%	-20.00%

1.big tank,no refill	undifferentiated	22.22%	0.00%
2.a variety of nursing modes to meet different needs	undifferentiated	20.00%	-20.00%

4.4. Use requirement importance ranking

To further prioritize the importance of each usage requirement and understand the degree of their impact, the Better-Worse coefficient was used to calculate the absolute values of B and W for the eight usage requirements S1-S8. Second-level sorting was performed on the usage requirement indicators of the same quality type. The sensitivity matrix was plotted using the absolute values of Better and Worse as the x and y coordinates, respectively. The data was then entered to clearly display the data. The “R” value represents the distance from the point to the origin of the matrix coordinates and indicates the sensitivity of each indicator to the user’s impact. The larger the R value, the higher the sensitivity and impact on the user. Comparing the R values can determine the importance of each indicator requirement, as shown in Figure 1.

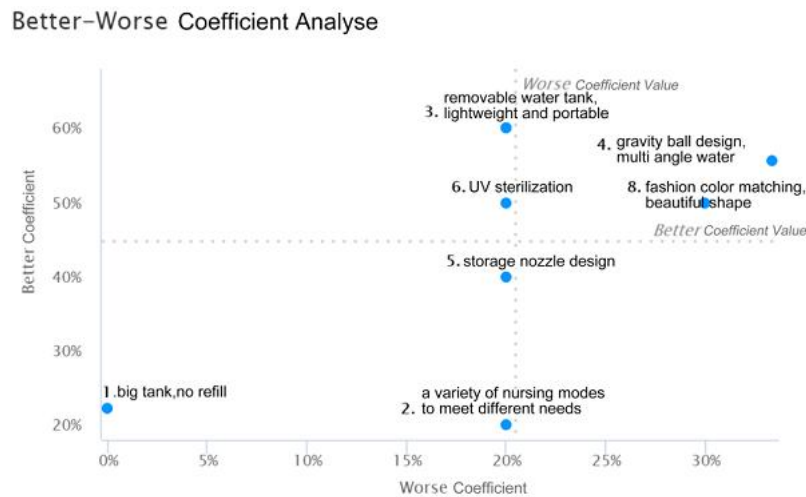


Figure 1. Coordinate graph.

4.5. Demand analysis

Based on the results of the quality type table and the importance ranking chart of design requirements, it can be seen that only “detachable water tank” and “ergonomic and easy-to-grip design” are attractive types among the 8 design requirements, while the others are mostly indifferent types. Further analysis can be conducted using the sensitivity matrix coordinate graph. The expected quality levels are ranked in the following order: 4 (gravity ball design, multi-angle water outlet), 8 (fashionable color matching, aesthetically pleasing appearance). The necessary type levels are ranked in the following order: 3 (detachable water tank), 6 (UV ultraviolet sterilization). There are many irrelevant quality indicators, which rank lower in the ranking.

From the above, it can be inferred that users are particularly concerned about elements such as aesthetic design, comfortable ergonomics, and ease of portability, in addition to meeting basic functions.

5. Design of Tooth Punch Based on Kansei Engineering

5.1. Identify a typical product sample

The KJ method was used to evaluate and analyze 50 mainstream products of different brands, styles, and functions of oral irrigators collected through the internet. Representative samples were selected, and ultimately 8 sample cases were obtained, as shown in Figure 2.

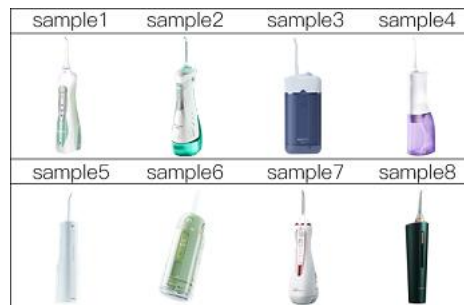


Figure 2. Oral irrigator samples.

5.2. Identify product perceptual vocabulary

The selection of emotional vocabulary is crucial as consumers' emotional intentions towards water flossers are often ambiguous. Various methods such as user interviews, literature review, and online research were used to collect emotional vocabulary. Based on the key requirements of the KANO model, including multiple care modes, gravity ball design, detachable water tank, nozzle storage design, UV sterilization, ergonomic grip, and aesthetic color, a preliminary list of 48 emotional words was collected. Similar words were eliminated, and 24 representative words were selected. To ensure the accuracy of the emotional vocabulary, multiple design experts and water flosser users were invited to participate in a second round of screening, merging similar words, and finally synthesizing 12 words as follows: high-end vs. low-cost, bright vs. plain, fashionable vs. traditional, smooth vs. rigid, simple vs. complex, and stable vs. lightweight. They are respectively numbered as 1, 2, 3, 4, 5, and 6 [9].

5.3. Design of questionnaire based on semantic difference method

In this study, eight sample cases of dental irrigators were photographed and labeled as numbers 1 to 8. A Likert 7-point scale questionnaire was designed using six pairs of emotional words, with scores ranging from -4 to +4. Participants, consisting of young users and students in industrial design and related fields, rated each sample according to their emotional perception. A total of 11 valid questionnaires were collected to obtain effective research data. The resulting typical sample emotional semantic evaluations were organized in Table 7, where the parameters represent the average values of the corresponding adjectives on a scale of 0 to 4. Negative values correspond to reversed image adjectives, while positive values correspond to the adjectives of the intended emotional words. The absolute value indicates the strength of the corresponding emotional image reflected by the sample.

Table 7. Semantic evaluation.

perceptual word pair	sample number							
	1	2	3	4	5	6	7	8
high-end—low-cost	0.73	0	1.09	-0.18	1.64	0.55	0.73	2.55
gorgeous—plain	-0.36	0.73	0.36	0.73	-0.36	1.45	0.18	1.09

fashionable—traditional	0.55	-0.36	1.09	0.73	1.45	2	-0.91	1.09
smooth—stiff	1.09	1.09	0.73	0.73	1.27	1.27	1.45	0.36
simple—complicated	0.73	-0.55	1.82	1.09	2.18	0.18	-0.18	1.27
stable—light	0.91	1.27	0.91	-0.91	0	-0.18	0.91	1.45

5.4. Data analysis

Based on the results obtained from the previous survey, the mean values of the 8 samples were taken to plot an image scale graph. “High-end” and “inexpensive” were marked as X1, with “high-end” and “inexpensive” corresponding to the positive and negative axes on the X-axis, respectively. “Bright” and “elegant” were marked as Y1, with “bright” and “elegant” corresponding to the positive and negative axes on the Y-axis, respectively.[10] In Table 7, the mean scores of Sample 1 in the evaluation of “high-end - inexpensive” and “bright - elegant” were 0.73 and -0.36, respectively, so the coordinates of Sample 1 are (0.73, -0.36). The same applies to the other samples, as shown in Figure 3.

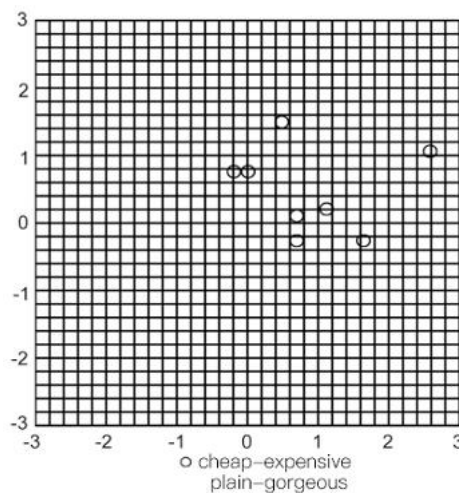


Figure 3. Intention scale.

Using the same method, the other 5 sets of emotional words were also labeled, and the analysis of the intention map shows that: there are a total of 4 samples in the first quadrant of the high-end and bright emotional word scale, 6 samples in the first quadrant of the fashion and fluent emotional word scale, and 3 samples in the first quadrant of the simple and steady emotional word scale. Based on the results of the graph, it can be concluded that the order of importance for the design requirements of the tooth washer is fashion and fluency, high-end and bright, and simple and steady.

5.5. Conclusions and recommendations

Based on the Kano quality types and importance ranking of the requirements for using a water flosser, as well as the research methodology of sensory engineering, the following conclusions can be drawn:

At the basic functional level of the water flosser, users have a need for outdoor use, therefore, they tend to prefer smaller and more portable styles. In addition, young people are more concerned about the appearance of the product. After satisfying the basic function, a striking and fashionable design will be more attractive to young consumers.

At the special functional level of the water flosser, there are no very obvious added value functions. Features such as spray nozzles that can be stored or UV sterilization cannot be the main selling points, nor the main breakthrough in design.

In terms of appearance, consumers' aesthetic needs have significantly increased. Traditional functional water flossers lack the beauty of line and color matching. Therefore, in design, the streamlining and color matching of the water flosser should be researched and designed to create an appearance that is ergonomically and artistically pleasing.

6. Conclusions

This study utilized the KANO model theory and the theory of Kansei engineering to conduct a detailed questionnaire survey on the functional, design, and appearance aspects of the design of a water flosser. The study obtained users' emotional needs for the function and appearance, and incorporated them into the final design. Starting from the demand as the starting point of the design is beneficial in providing directional guidance in the pre, middle, and post stages of the design, and designing a water flosser that meets consumers' needs. The limitations of this study are the small sample size and lack of comprehensiveness, which need to be improved.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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